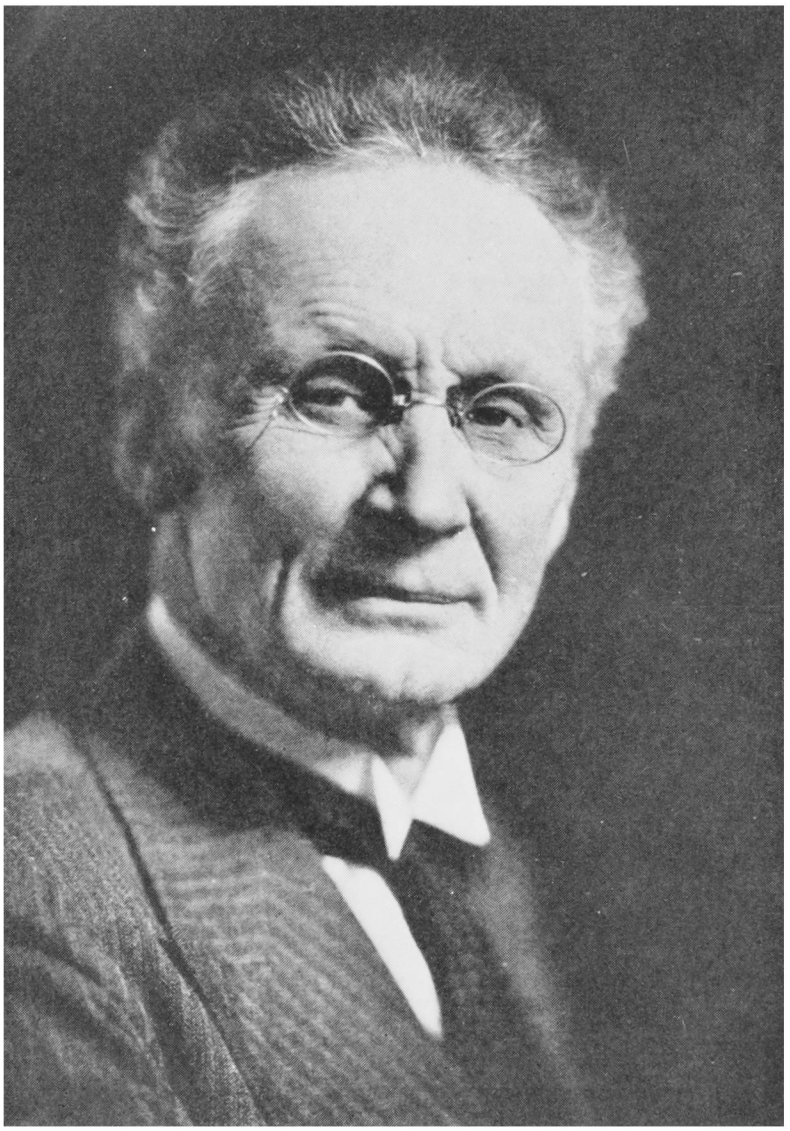

V. Bjerknes

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M.O. 548 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

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VILHELM F. K. BJERKNES, For. Mem. R. S.

We deeply regret to have to record the death of Professor V. F. K. Bjerknes, which occurred at Oslo on April 9, 1951. He was 89 years old.

His name will live in meteorological history for his circulation theorems, his introduction into meteorology of the use of the absolute units of pressure, of geopotential and of charts of the topography of isobaric surfaces, and for his work on the theory of the oscillations of rotating fluids.

Three generations of the Bjerknes family have become internationally famous for research into the dynamics of fluids as C. A. Bjerknes, the father of V. Bjerknes was an eminent research worker in the theory of the hydrodynamics of " perfect " fluids, while the name of J. Bjerknes, one of the three sons of V. Bjerknes, is known to all meteorologists.

V. Bjerknes was born at Oslo on March 14, 1862, and educated at Oslo University where his father was Professor of Mathematics. While still a student he assisted in his father's researches and published his first paper, " New investigations in hydrodynamics "[1], at the age of 20 in 1882. He studied under Hertz from 1890 to 1891, and for several years afterwards his attention was mainly devoted to electrodynamics. Throughout his life he sought for analogies between hydrodynamics and electrodynamics.

In 1893, the year of his marriage to S. H. Bonnevie, he was appointed Professor of Mechanics and Mathematical Physics at the University of Stockholm, and while there he made, in 1898, his first major contribution to physical hydrodynamics in the theorem[2] for the rate of change of circulation in a baroclinic fluid. The mathematical formula was first published in 1896 in Poland by Silberstein but it was independently discovered by Bjerknes. Silberstein gave no physical applications of the theorem but Bjerknes saw its physical importance and gave numerous instances, such as the theory of sea breezes, of its applications in meteorology and oceanography[3]. His next major theorem was the formula[4] for the circulation in circuits on the rotating earth, published in 1901, with such applications as " A horizontal curve which contracts acquires cyclonic, one which expands, anticyclonic curvature." Between 1901 and 1907 Bjerknes worked in collaboration with J. W. Sandström on the application of these hydrodynamical theorems to meteorology, and conceived a plan for weather forecasting by graphical integration of the equations of motion which he described in the first article[5] of the 1904 volume of the *Meteorologische Zeitschrift*, " The problem of weather forecasting from the standpoint of mathematics and physics". An essential part of the scheme was the representation

(diagnosis) of the existing state of the atmosphere in a convenient graphical form, and it was in a paper, " Aids to the calculation of the pressure distribution of the atmosphere during the international days of 1900 to 1903"[6], on this subject, that Bjerknes and Sandström introduced the absolute unit of pressure and employed geopotential as a measure of elevation. Following a visit to the United States in 1905 Bjerknes became a Research Associate of the Carnegie Institution which thereafter assisted him financially in his researches.

In 1907 Bjerknes was appointed Professor of Mechanics and Theoretical Physics at Oslo University. While at Oslo, he, in collaboration with Sandström, Hesselberg and Devik, produced his "Dynamic meteorology and hydrography"[7] published in two volumes, Part I: Statics and Part II: Kinematics, by the Carnegie Institution in 1910 and 1911 and devoted to calculations and graphical methods for the establishment of a satisfactory diagnosis of the state of the atmosphere. In this work the use of the topography of isobaric surfaces was proposed for the first time, and the relation, independent of air density, between the gradient of geopotential on such a surface and the geostrophic wind was pointed out. During this period, too, he played a prominent part[8] in the international acceptance of the millibar and the strong controversies associated with that subject.

Bjerknes paid his first visit to the British Isles in 1910. He came primarily to discuss with Sir Napier Shaw his methods and the making of observations suitable for accurate dynamical analysis. He delivered a lecture[9] (May 27, 1910) at University College, London, on the synoptic representation of atmospheric motions which was mainly concerned with the construction of charts of wind flow in the upper air and their use in the computation of the vertical currents.

The University of Leipzig decided in 1912 to establish a Geophysical Institute which V. Bjerknes was invited to direct as Professor of Geophysics. In his inaugural lecture[10], January 1913, he expressed his intention of directing all the energies of the new Institute to the calculation of the future state of the weather. Elsewhere, he has stated that on this basis he refused to take charge of the seismological work of the University. Stimulated at this time by a study of Helmholtz's paper of 1888 on " Atmospheric motions", and by von Ficker's papers on the spreading out of cold air over Siberia, Bjerknes was led to consider whether cyclones might originate as waves, and began the study[11] of wave motion in rotating compressible fluids.

Conditions at Leipzig became more and more difficult as the German students were mobilized for war service, so that in 1917 Bjerknes accepted an invitation to direct the Bergen Geophysical Institute to which he took his Norwegian " Carnegie Assistants " J. Bjerknes and H. Solberg who were joined later by T. Bergeron.

The study of lines of convergence and their association with changes of temperature had been commenced by Pezold, a German student at Leipzig, who was killed in the war. This work was taken over by J. Bjerknes and H. Solberg, and, with the aid of the observations from the dense network of observing stations set up in Norway during the war in an effort to mitigate the loss of foreign reports, led to the universally known doctrines of air masses and fronts.

In 1920 V. Bjerknes and Helland Hansen invited Sir Napier Shaw and three other British meteorologists (L. F. Richardson, A. H. R. Goldie and C. K. M. Douglas) to visit the Bergen Geophysical Institute to take part in a series of meetings on dynamical meteorology at which the new Bergen theory was discussed. The enthusiasm of the Bergen research school, the kindness and hospitality of its members greatly impressed the visitors.

V. Bjerknes's part in the Bergen work lay largely in the theoretical interpretation, contained in his large works[12] on the dynamics of the circular vortex and in shorter papers[13] on the linearized hydrodynamical equations of small disturbances, of the empirical discoveries of his young collaborators. The team divided in 1926 when V. Bjerknes returned to his old chair at Oslo taking with him the mathematician Solberg. He retired from this post in 1932.

The work of his whole career was summed up in the great work, " Physical hydrodynamics with applications to dynamical meteorology "[14] written by V. and J. Bjerknes, H. Solberg and T. Bergeron and published in 1933.

V. Bjerknes made numerous visits to this country after 1919. In 1919 he lectured to the Royal Meteorological Society on " The structure of the atmosphere when rain is falling[15], and in 1924 to the Royal Institution on "The forces which lift aeroplanes"[16] and to the Royal Meteorological Society on " Polar-front meteorology"[17]. In 1927 he visited Edinburgh and St. Andrews in company with Nansen, Helland Hansen and Sverdrup when that gallant band renewed many old acquaintanceships.

In 1936 he presided over the Edinburgh meetings of the International Association of Meteorology to which he read a paper[18] on the application of his circulation theorems to the general circulation of the atmosphere and its oscillations. And in 1946 on the occasion of the deferred Newton Tercentenary Celebrations he was a delegate with Størmer to the Royal Society.

Outside his purely meteorological papers may be mentioned one on " Solar hydrodynamics "[19] inspired by his discussions with the astronomers of the Mount Wilson Observatory in 1924. This is a " hydrodynamical discussion of internal solar motions, especially vortex motions, for explaining sunspots and their properties"—a paper which has also much interest for the meteorologist.

To mention V. Bjerknes's British honours only, he was a Foreign Member of the Royal Society (1933) and of the Royal Society of Edinburgh (1930), Honorary Member of the Royal Meteorological Society (1913), Symons Medallist (1932), and LL.D. Hon., St. Andrews (1926).

REFERENCES

1. Nyere hydrodynamiske Undersøgelser. *Naturen, Bergen*, 6te Aarg., 1882, p. 132.
2. Über die Bildung von Cirkulationsbewegungen und Wirbeln in reibungslosen Flüssigkeiten. *Skr. VidenskSelsk., Kristiania*, 1898.
3. Über einen hydrodynamischen Fundamentalsatz und seine Anwendung besonders auf die Mechanik der Atmosphäre und des Waltmeeres. *K. svenska Vetensk Akad. Handl., Stockholm*, **31**, 1898, No. 4.
4. Cirkulation relativ zu der Erde. *K. svenska Vetensk Akad. Forhandl., Stockholm*, **34**, 1901, p. 739.
5. Das problem der Wettervorhersage betrachtet vom Standpunkte der Mechanik und der Physik. *Met. Z., Wien*, **21**, 1904, p. 1.
6. (With SANDSTRÖM, J. W.) Hilfsgrössen zur Berechnung der Druckverteilung in der Atmosphäre an den internationalen Tagen 1900–1903. *Beitr. Phys. frei Atmos., Strassburg*, **2**, 1906, p. 1.
7. Dynamic meteorology and hydrography: Part I (with SANDSTRÖM, J. W.). Statics. 1910, Part II (with HESSELBERG, TH. and DEVIK, O.). Kinematics. 1911. Carnegie Institution, Washington, D.C.

8. Millimeter oder Millibar? *Met. Z., Braunschweig*, **29**, 1912, p. 576.
9. Synoptical representation of atmospheric motions. *Quart. J. R. met. Soc. London*, **36**, 1910, p. 267.
10. Die Meteorologie als exakte Wissenschaft. Antrittsvorlesung gehalten am 8 Januar 1913 in der Aula der Universität Leipzig. Braunschweig, 1913.
11. Über Wellenbewegungen in kompressiblen schweren Flüssigkeiten. *Abh. sächs. Ges. (Akad.) Wiss., Leipzig*, **35**, No. 2, 1916.
12. On the dynamics of the circular vortex with applications to the atmosphere and atmospheric vortex and wave motions. *Geofys. Publ., Kristiania*, **2**, No. 4, 1921.
13. Über die hydrodynamischen Gleichungen in Lagrangescher und Eulerscher Form und ihre Linearisierung für das Studium kleiner Störungen. *Geofys. Publ., Oslo*, **5**, No. 11, 1929.
14. (With BJERKNES, J., SOLBERG, H., and BERGERON, T.) Physikalische Hydrodynamik mit Anwendung auf die dynamischen Meteorologie. Berlin, 1933.
15. The structure of the atmosphere when rain is falling. *Quart. J. R. met. Soc., London*, **46**, 1920, p. 119.
16. The forces which lift aeroplanes. *Nature, London*, **114**, 1924, pp. 472 and 508.
17. Polar-front meteorology. *Quart. J. R. met. Soc., London*, **51**, 1925, p. 261.
18. De l'application des théorèmes de circulation à la discussion des phénomènes atmosphériques. *P. V. Mét. Un. géod. géophys. int.*, 6ième Assemblée Edimbourg 1936, II: Mémoires et Discussions, p. 7. Paris, 1939.
19. Solar hydrodynamics. *Astrophys. J., Chigaco Ill.*, **44**, 1926, p. 93.

DISTRIBUTION OF RAINFALL ROUND A HOUSE

By R. E. LACY, B.Sc.

Summary.—Measurements have been made of the rain collected in a number of rain-gauges set up round a house. The results of the first eight months' observations are presented. Over this period an area round the house equal in area to the house itself received less than the normal amount of rain. The results are also used to demonstrate the effect of shelter on the catch of rain-gauges.

Introduction.—In connexion with work on house foundations it was required to determine what quantity of rain fell close to the house, and how this quantity varied with distance from the walls. Accordingly, in the autumn of 1948 a number of rain-gauges were set up as indicated in Fig. 1, at various points round a house at the Building Research Station. The exposure of the house is not as good as could be desired, as there are buildings fairly close in all directions from north-west to east, but since most rain falls with winds from the south to west their effect on the results was probably small. No house with a clearer exposure was available. Fig. 2 (facing p. 212) is a photograph of the house taken from the north. The present note sets out and comments on the results obtained during the first eight months of the experiment.

Experimental method.—The rain-gauges used were Meteorological Office Mark II 5-in. diameter rain-gauges, with the lips of the collecting funnels set at the standard height of 12 in. above ground level.

Gauges 3, 4, 7 and 8 were placed as close as possible to the walls, with the other gauges at various distances from the west, north and east walls. It was not possible to put a second gauge at a suitable distance from the south wall. Gauge 1 was placed 18 ft. from the north wall, a distance equal to the height of the house eaves above ground level. The house has a tiled roof pitched at 40°, with a gutter projecting 12 in. beyond each wall.

The gauges were read, not at fixed intervals, but at the conclusion of periods of rain falling with one direction of wind, as far as this was possible, so that the variation in the pattern of the rainfall with wind speed and direction could

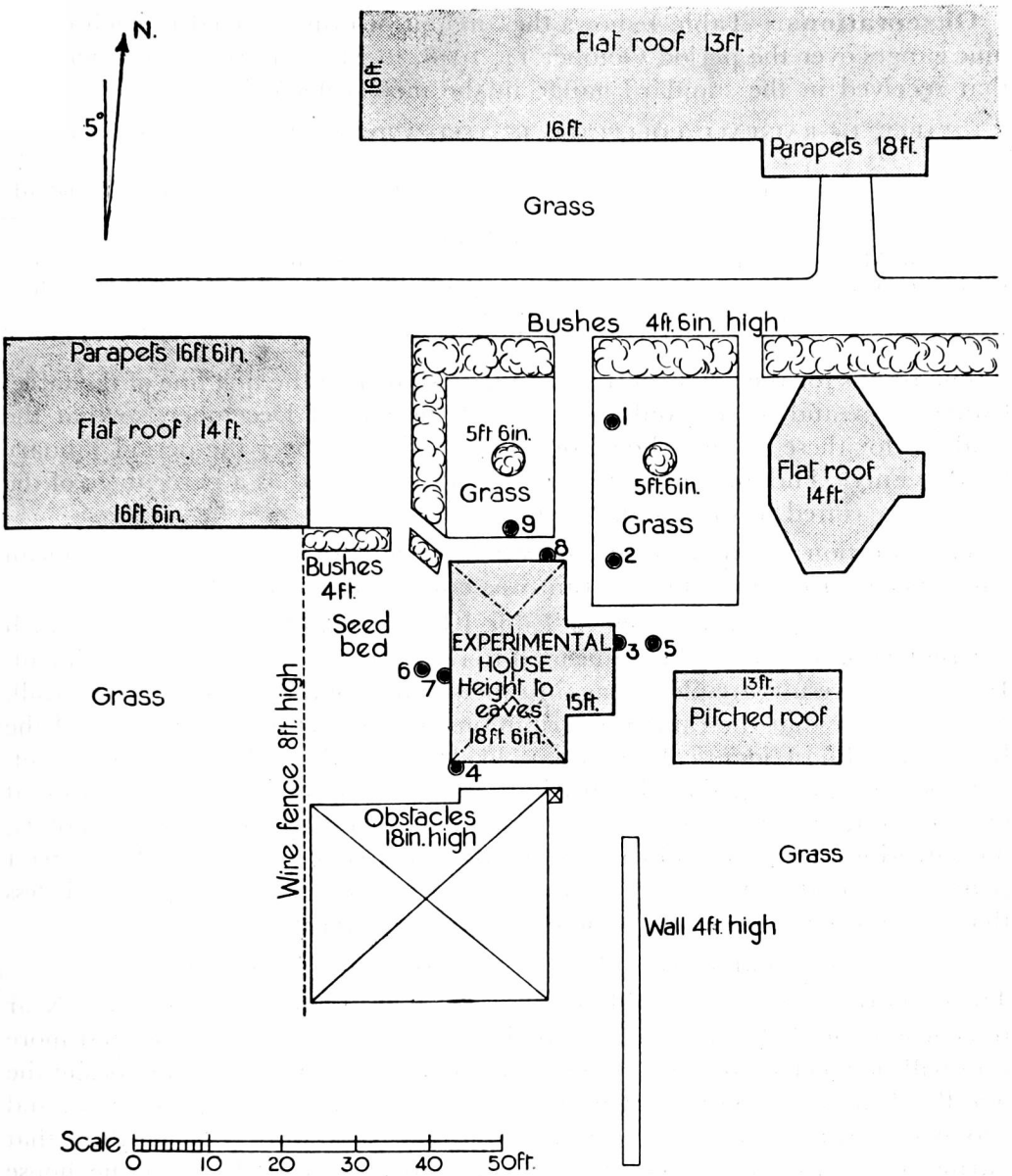


FIG. 1—POSITION AND EXPOSURE OF THE RAIN-GAUGES

be obtained. The periods of rainfall discussed below do not therefore coincide with particular rain days, but may in some cases comprise a rainfall over part of a day, or in other cases may cover several days' rain.

The times at which rain fell were determined from a Meteorological Office tilting-siphon rain recorder situated in the meteorological enclosure some 200 yd. from the house, where the standard 5-in. gauge was also placed. The wind speed during the rain was determined from a wind-run recorder driven by a cup contact anemometer mounted on a 10-ft. high mast, which was set up on a flat roof 16 ft. above ground level. It was not possible to install an anemometer in a better position near the house. Wind direction was obtained from the records of a directional wind recorder at Abbotts Langley, one mile away.

Observations.—Table I shows the amount of rain received in each of the nine gauges over the period October 11, 1948, to May 31, 1949, together with that received in the standard gauge in the meteorological enclosure.

TABLE I—RAINFALL COLLECTED IN TEST AND STANDARD RAIN-GAUGES

	TEST GAUGES									Standard
	1	2	3	4	5	6	7	8	9	
	millimetres									
October to May	331·9	320·0	75·4	...	...	338·1	259·6	...	282·7	337·2
January to May	...	...	...	124·3	147·9	...	...	51·7	...	167·8
	per cent.									
	98·4	94·9	22·4	74·1	88·2	100·3	77·0	30·9	83·8	100

The results for the whole of the period are shown on the first line of the table. Gauges 4, 5 and 8 were only installed at the end of December, so that the readings for these gauges, shown on the second line, cover the period January to May only. The third line shows the results expressed as a percentage of the rainfall measured in the standard gauge.

The duration of rainfall over the whole period was 243 hr. and the mean wind speed during the time the rain was falling was 6·0 m.p.h.

The percentage figures given in Table I have been plotted in Fig. 3, which is a replica of one of the diagrams used to record the results of this experiment. In Fig. 4 the results are plotted against the distance of the gauges from the wall, and it is clear that the rainfall distributions on the east and north sides of the house are almost identical. It seems likely, from the value of 74 per cent. obtained for gauge 4, that the distribution on the south side is similar to that on the west, and two curves have therefore been drawn through the points, one covering the north and east points, the other covering the south and west points. From the curves it is estimated that the distances within which less than the normal amount of rainfall was received were:

north and east 8 ft. south and west 3 ft.

These figures apply to the middle of the walls, away from the corners. Near the corners the sheltering effect of the house will not be so great, so that more rain will be received on the ground near the house than at points opposite the middle of the wall. With the help of the curves of Fig. 4, the 50 per cent. and 100 per cent. isopleths have been drawn in Fig. 3. It appears from these that during the period under consideration an area of ground round the house approximately equal to the area of the house itself received less than the normal amount of rain. Nearly 10 per cent. of this area received less than half the normal amount.

Effect of shelter on rain-gauges.—The results have been used in the preceding section to estimate the amount of shelter given by the house to the surrounding ground. Table II sets out the percentage readings for the nine gauges by months, together with wind speed, duration of rainfall, and rainfall in the standard gauge.

It will be seen that apart from gauge 9, 4 ft. from the north wall, only the inner gauges, 3, 4, 7 and 8, set under the eaves of the house, show very marked differences from the readings of the standard gauge. This is also shown by Table III, which gives the mean value for each of the test gauges, together with the corresponding standard deviation of the monthly totals, which is a measure of the variability of the observations from month to month.

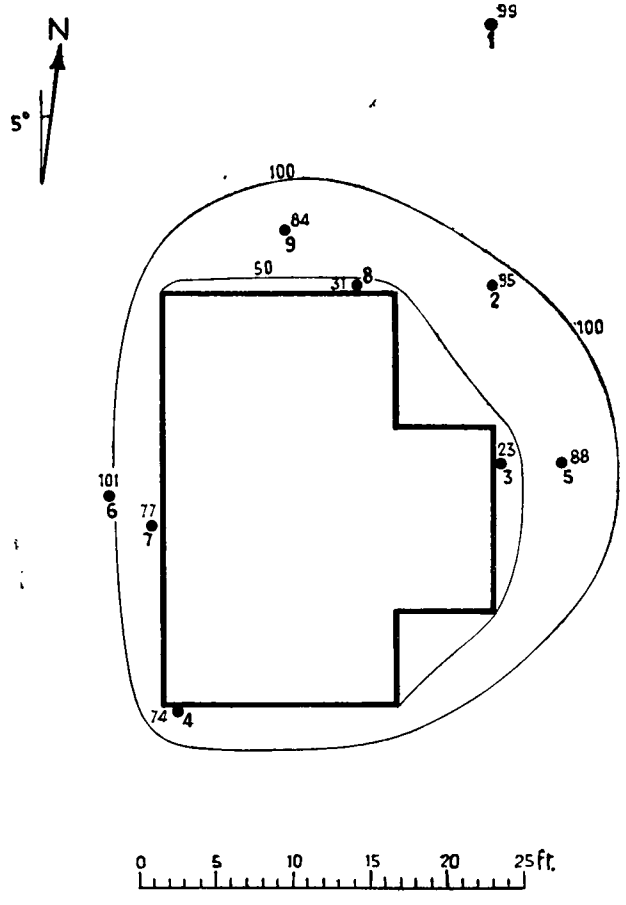


FIG. 3—RAINFALL MEASUREMENTS ROUND EXPERIMENTAL HOUSE, EXPRESSED AS A PERCENTAGE OF STANDARD

Rainfall (standard gauge), 13·28 in. Period, Oct. 11, 1948–May 31, 1949.
Duration of rainfall, 243 hr. Mean wind speed, 6·0 m.p.h.

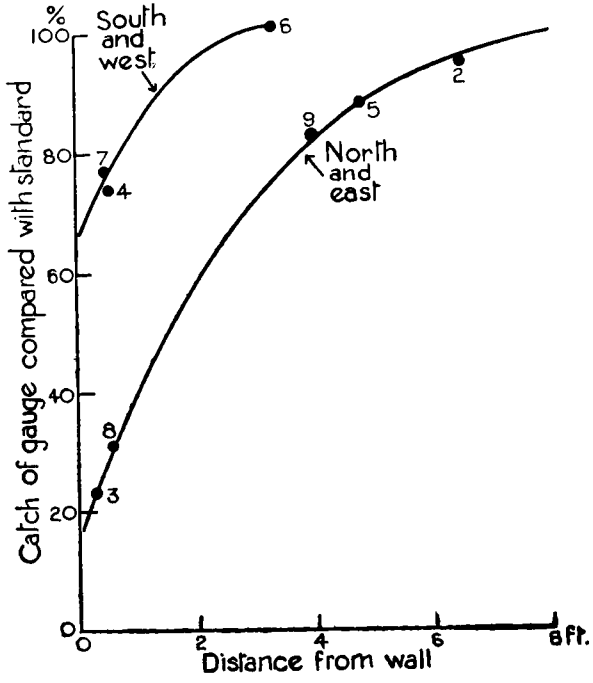


FIG. 4—VARIATION OF RAINFALL WITH DISTANCE FROM WALL

TABLE II—MONTHLY READINGS OF RAIN-GAUGES

Period	Duration	Wind speed	TEST GAUGES 1	2	3	4	5	6	7	8	9	Standard
1948–49	hr.	m.p.h.	*percentage of standard*									mm.
Oct. 11–31	27·2	4·0	101	97	16	—	—	105	94	—	92	50·0
Nov. 1–30	35·4	5·4	100	100	43	—	—	95	55	—	95	46·8
Dec. 1–Jan. 2	49·2	7·5	96	85	12	—	—	101	89	—	67	72·6
Jan. 3–31	22·8	4·7	101	98	43	87	81	98	54	28	84	21·4
Feb. 1–26	23·6	7·2	100	96	36	99	85	94	80	23	68	34·9
Feb. 27–Mar. 21	22·5	4·4	100	101	25	90	96	102	69	27	92	31·8
Mar. 22–Apr. 30	31·7	8·5	95	96	11	53	82	103	93	56	90	37·8
May 1–31	30·4	4·5	96	96	15	54	94	102	62	19	93	41·9

TABLE III—MEAN MONTHLY PERCENTAGES AND STANDARD DEVIATIONS OF MONTHLY PERCENTAGES OF TEST RAIN-GAUGES

Gauge	1	2	3	4	5	6	7	8	9
Mean percentage	98·6	96·1	25·1	76·6	87·6	100·0	74·5	30·6	85·1
Standard deviation of percentages	2·5	4·9	13·7	21·5	7·0	3·9	16·7	14·6	11·3

It would appear that if monthly readings only are considered, gauge 1, 18 ft. from the house (giving a shelter ratio of approximately 1:1) and on the side which is sheltered from the prevailing winds, gives a measure which may well be acceptable as a measure of the true rainfall. This somewhat unexpected result is probably to be explained by the fact that the experimental site is to some extent sheltered by a belt of trees about 200 yd. to the south, as a result of which the mean wind speed in the neighbourhood of the house is never very high, being little more than half that at a well exposed site about a mile to the west. It was shown by Hudleston at Hutton John[1,2], in a district freely exposed to wind, that a rain-gauge with a shelter as severe as that of gauge 1 will catch only 60 per cent. or less of the true rainfall in a strong wind.

Gauge 6, only 3 ft. from the west wall of the house, has a mean monthly catch of 100·0 per cent., with a standard deviation of 3·9 per cent. It is exposed to the majority of the rain-bearing winds, and will also catch a little rain with an easterly wind, if the wind strength is not too great. Even this gauge may therefore be expected to give fairly reliable monthly totals of rainfall if there is the normal proportion of W. and E. winds.

However the variability of short-period totals is much greater: 38 sets of readings were obtained during the period under consideration, some of these, as indicated above, comprising falls over more than one day, and for these, again expressed as percentages of the catch in the standard gauge, the mean for gauge 1 is 96·8 per cent., with a standard deviation of 7·2 per cent.

During the period October 11 to December 18, 1948, when 13 separate sets of readings were obtained, a gauge, A, was situated 36 ft. south of the house, and, there being no other near-by obstructions, could be considered to have a "normal" exposure as recommended in the "Meteorological observer's handbook". Considering the readings of gauges A, 1 and 6 for this period we have:—

Gauge No.	A	1	6
		per cent.	
Mean of 13 observations	103·6	99·8	95·0
Standard deviation ...	3·8	4·8	29·2

The correlation between the standard and gauge A is good, although over this period A tended to read higher than the standard. Gauge 6, which gave monthly readings closely agreeing with those of the standard, shows up badly when individual readings are considered, due to the considerable shelter given by the house from rain falling with easterly winds. The standard deviation of the readings of gauge 1 is only a little greater than that of readings of gauge A, from which it is concluded that some of the variation is due to real differences between the rainfall at the site of gauge 1 and that at the meteorological enclosure, only part of the variation being due to the effects of shelter.

REFERENCES

1. HUDLESTON, F.; Report on experiments with rain-gauge shields and rain-gauges under the lee of a high wood during the period 1st May, 1928, to 30th April, 1929, Hutton John, Penrith. *Brit. Rainf. 1928, London*, 1929, p. 258.
2. HUDLESTON, F.; Report on experiments with rain-gauge shields and rain-gauges under the lee of a high wood during the period 1st May, 1929, to 30th April, 1930, Hutton John, Penrith. *Brit. Rainf. 1929, London*, 1930, p. 288.

VARIABILITY OF PERCENTAGE ANNUAL RAINFALL OVER SHORT DISTANCES IN SCOTLAND

By R. A. WATSON, B.A.

Two rain-gauges situated a few miles apart are often used as a check on each other's readings, but so far as is known no numerical measure of the difference has actually been observed between pairs of such gauges. Measures of this sort are necessary in attempting to assess the accuracy of the estimated rainfall over a catchment area from the readings of a number of gauges over the catchment.

If R_x and R_y are the mean annual rainfalls at two neighbouring places X and Y, and $x_1, x_2, x_3 \ldots\ldots, y_1, y_2, y_3 \ldots\ldots$ are the departures of the observed rainfall in successive years expressed as a percentage of R_x and R_y it is reasonable to assume, and actual test verifies, that $\Sigma x_1^2 = \Sigma y_1^2$ and therefore

$$\frac{\Sigma (x_1 - y_1)^2}{\Sigma x_1^2} = 2(1 - \rho)$$

where ρ is the correlation coefficient between the annual rainfall at X and the annual rainfall at Y both expressed as a percentage of the mean or

$$\frac{\text{Standard deviation of the percentage difference}}{\text{Standard deviation of the rainfall}} = \sqrt{\{2(1-\rho)\}}$$

This means that the ratio is only reduced to 0·5 even if the correlation coefficient is 0·875.

In *British Rainfall 1925* Glasspoole worked out the correlation of annual rainfall at a large number of places with Glenquoich and with Oxford. His maps cannot be used to determine the correlation between places only a few miles apart, but it is interesting to note that only a very small area of Scotland is shown as having a correlation with Glenquoich greater than 0·8. On the other hand half the area of England and Wales is enclosed within the 0·8 correlation line with Oxford.

Except near the large towns there exist few pairs of gauges which have been in operation for a sufficiently long time without some change, but figures for the pairs in Table I were worked out for the 25-year period 1926–50. Even in these selected places there are known to be some breaks in the continuity of the record but it is hoped that these are not important.

TABLE I—COMPARISON OF NEIGHBOURING RAIN-GAUGES IN SCOTLAND

County or district	Position of gauges	Distance apart	Standard deviation	Standard deviation of difference	Correlation coefficient
		miles	%	%	
Edinburgh	Royal Botanic Garden Royal Observatory	3	13·8	3·8	0·96
Wigtown	Port William (Monreith) Garlieston (Galloway House)	7	14·2	5·5	0·93
Argyll	Strachur Park Inveraray (Castle Gardens)	5	18·0	8·0	0·90
Aberdeen	Aberdeen (Mannofield) Dyce (Craibstone)	5	10·0	5·1	0·87
Loch Linnhe	Ardgour House Onich	3	19·3	7·5	0·93
Argyll	Islay (Eallabus) Islay (Rhuvaal)	11	12·3	6·3	0·89
Renfrew	Loch Thom Inverkip	3	15·0	7·6	0·87
Shetland	Lerwick Observatory Bixter	16	11·5	5·8	0·87
Hebrides	Tiree	...	14·4	...	...

There was no significant difference between the standard deviations of rainfall at the two places compared. It is not safe from so few pairs to attempt any generalization as to the geographical distribution of the standard deviation of the differences. The big values may well be associated with larger rainfall or with sharper relief of the land, but except for the very small value for the two Edinburgh stations the most striking fact is that the figures are so nearly grouped round a mean of about 7 per cent. This means that, if we express the year's rainfall of two closely neighbouring places as a percentage of the long-period average, we must expect differences of over 7 per cent. in about one out of three cases and even differences of 14 per cent. in one out of twenty cases without, from this fact alone, raising suspicion of the correctness of the observations. The ordinary practice of comparison always takes into account factors other than the mere differences from neighbouring records.

In the article in *British Rainfall* already mentioned, Glasspoole worked out the standard deviations of annual rainfall at a number of places in the British Isles for the period 1881–1915. The differences between Glasspoole's values for the earlier period and those now worked out are not large, but, such as they are, suggest that the annual rainfall was somewhat less variable than in the standard 35-year period than in the one now considered especially in the west of Scotland. To test this the standard deviation for Tiree was worked out and is recorded in Table I. Unfortunately, there was a change of site of the rain-gauge on Tiree in 1942. Any lack of continuity in the records is liable to increase the standard deviation. Although the increase at Tiree from this cause is probably small it cannot be evaluated with any certainty as yet owing to the isolated position of the record.

HONOURS AND AWARDS

Charles Chree Medal and Prize

Sir George Simpson, F.R.S., has been awarded the Charles Chree Medal and Prize of the Physical Society for distinguished work in terrestrial magnetism and atmospheric electricity.

METEOROLOGICAL RESEARCH COMMITTEE

The Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee held meetings (14th and 15th respectively) on May 10 and 23, 1951. Dr. A. W. Brewer (Clarendon Laboratory, Oxford) has recently become a member of this Sub-Committee.

At the first of these meetings the main discussion was concerned with investigations which might help to improve the forecasting of fog. In this connexion Mr. J. M. Craddock presented a paper[1] on forecasting radiation fog. Papers on the structure of the tropopause surface[2] and the distribution of high and medium cloud near the jet stream[3], the former by Mr. J. S. Sawyer and the latter by Mr. J. S. Sawyer and Miss B. Ilett, were also discussed.

At the second meeting there was a long discussion of the validity and value of the various approximations made in the Rossby, Charney and Sutcliffe approaches to the short-term dynamics of the atmosphere. Mr. H. H. Lamb's report[4] on an attempt to classify the circulation patterns of the northern hemisphere was also discussed and invoked considerable interest; it appears that a workable classification is not possible for the hemisphere. Other papers discussed were by Mr. A. H. Gordon[5] on seasonal changes in the mean pressure distribution over the world (largely based on observations from ships), and by Mr. F. H. Bushby[6] giving a second report on tests of the Charney-Eliassen method of computing forecast 500-mb. contour charts; the latter paper deduces that forecasts by conventional methods are more accurate than the computed.

The sixteenth meeting of the Physical Sub-Committee of the Meteorological Research Committee was held on May 17.

An interesting paper[7] by Mr. N. E. Rider on the relation between aerodynamic drag and wind profile over grassland was considered.

A paper by Dr. Brewer and Mr. Palmer on the freezing of supercooled water was also discussed. The results of this work refute the claim of Rau that pure water can be supercooled to −72°C. by repeated freezing and melting.

The Committee considered a report on the frequency of jet streams over the British Isles and also a short note on some statistics of rate of rainfall in southern England.

[1] *Met. Res. Pap., London*, No. 624, 1951.
[2] *Met. Res. Pap., London*, No. 612, 1951.
[3] *Met. Res. Pap., London*, No. 633, 1951.
[4] *Met. Res. Pap., London*, No. 632, 1951.
[5] *Met. Res. Pap., London*, No. 646, 1951.
[6] *Met. Res. Pap., London*, No. 622, 1951.
[7] *Met. Res. Pap., London*, No. 626, 1951.

ROYAL METEOROLOGICAL SOCIETY

Physics of natural rain formation

The Annual General Meeting of the Society was held in the Society's rooms, 49 Cromwell Road, on Wednesday April 18, 1951, with the President, Sir Robert Watson-Watt, in the Chair. After the adoption of the report of the Council for the year 1950, the President presented the Symons Gold Medal to Sir Geoffrey Taylor, M.A., F.R.S., Yarrow Research Professor of the Royal Society, in recognition of his classical work in atmospheric turbulence and related subjects in meteorology.

There then followed an ordinary meeting at which Dr. E. G. Bowen, Director, Radio Physics Division, Commonwealth Scientific and Industrial Research Organization, Australia, gave a lecture on recent work by his division into the physics of cloud and rain.

Dr. Bowen said that his division's work could be divided into three distinct parts: cloud physics, the physics of natural rain formation, and studies of artificial rain formation. He confined his lecture to the second of these subjects.

In the main observations had been made with 10-cm. radar sets which can detect raindrops, snow-flakes or ice particles provided they are big enough, the intensity of echo being proportional to $\Sigma ND^6/\lambda^4$ where N is the number of raindrops of mean diameter D and λ the radar wave-length. These observations could be taken either on the ground or in the air, and were so arranged as to give vertical cross-sections through regions of rain. Dr. Bowen showed 4 slides of radar observations, taken from an aircraft, of rain falling from a cloud, no part of which at any time reached the freezing level. The rain was falling into " wild " country near Sydney, and it was therefore not possible to quote actual intensities of the rainfall but the echo was very similar to that given by measuring rainfall intensity of 5 mm./hr.

This clear-cut contradiction of the Bergeron theory[1] of rain formation (that all appreciable rain is produced by the melting of ice crystals) required explanation, and Dr. Bowen described his coalescence theory of rain formation in which all cloud and rain droplets are assumed to coalesce on impact. With this assumption, and, accepting Langmuir's formula for the collection efficiency of a drop falling through a cloud of smaller droplets, the growth of drops has been calculated in differing cloud conditions of varying vertical air velocities. A typical result, with a vertical air velocity of 100 cm./sec. in a cloud of water content 1 gm./m.[3] and average droplet size of 20μ, gave a drop growing in size more and more rapidly, its terminal velocity overcoming the up-draught at a height of 7,000 ft. above the cloud base, and eventually falling out of the cloud as a raindrop with diameter about 1·5 mm., the whole operation taking about an hour. Higher vertical air velocities gave larger raindrop sizes and drops reached greater heights; increase in water content increased the size of the raindrops only slightly but reduced the cloud thickness traversed; decreased collection efficiency decreased the raindrop size only slightly but required a greater increase in cloud thickness; and increase in average size of cloud droplet gave relatively small changes in both raindrop size and cloud thickness.

The number of raindrops per unit volume of cloud is given by $N=n/(v-u)$ where n is the number of drops crossing unit area, v is the upward air velocity and u the terminal velocity. This number, and therefore the rain-water content, must become very large near the top of the trajectory of a growing drop. This concentration of rain-water at a definite level had been confirmed by experience at a height half-way up the cloud.

Dr. Bowen showed slides of theoretical and observed variation with height of both raindrop density (N) and rain-water content, and the curves were of the same general form. He also showed radar photographs of rain coming from clouds whose tops were limited by an inversion below the freezing level, and drew attention to 200–300 mm. of rain per year occurring in Hawaii with a regular trade-wind inversion at 10,000–12,000 ft. (i.e. below the freezing level.)

Dr. Bowen went on to show radar photographs of rain falling from cloud which had been produced by the Bergeron process, and, in addition to the bright band visible near the freezing level (due to the melting of ice crystals), he showed the occasional existence of a further bright band formed some 8,000 ft. higher than the freezing level due, he thought, to a sudden freezing of supercooled drops at that level. In this connexion he gave an outline of recent work in the United States on the spontaneous freezing of supercooled drops.[3]

In conclusion, a film was shown of what occurs on a radar screen, but speeded up some 120–150 times. Both the freezing-level band and the upper band were seen. The upper band forms and almost immediately begins to fall towards the freezing-level band; when the bands meet the rain suddenly intensifies. The upper band then reforms at a higher level and repeats the process. Other sequences in the film showed shower echoes quite clearly below the freezing level, and one occasion with both Bergeron and coalescence processes acting together to produce rain.

In the brief discussion that followed the lecture some doubt was raised about the explanation given for the upper bands; Dr. Bowen agreed there were still considerable cracks in the theory. Mr. Ludlam stated that there had been no previous convincing evidence of rain falling from cloud below freezing level; he was now forced to admit that it did occur.

REFERENCES

1. BERGERON, T.; On the physics of cloud and precipitation. *P. V. Mét. Un. géod. geophys. int., Paris*, 1935, II, p. 156.
2. RYDE, J. W.; The attenuation of radar echoes produced at centimetre wave-lengths by various meteorological phenomena. " Meteorological factors in radio-wave propagation ". London, 1946, p. 169.
3. HEVERLY, J. R.; Supercooling and crystallization. *Trans. Amer. geophys. Un., Washington D.C.*, **30**, 1949, p. 205.

Presidential Address

Sir Robert Watson-Watt, F.R.S., delivered his Presidential Address on the subject " Meteorology and aviation " before the meeting of the Society held on May 16, 1951.

Sir Robert discussed the history of the AIRMET broadcasts in the first part of his address. He gave a summary of the development of these broadcasts and of their cancellation a year ago following the re-allocation of the frequency used for them at the Copenhagen International Broadcasting Conference of 1948. He emphasized that the AIRMET broadcasts, though arranged initially for the use of aviators, had come to be widely used by many other members of the community. He was strongly of the opinion that the five-minute B.B.C. broadcasts of Meteorological Office forecasts were no substitute for AIRMET with its intimate contact with the actual forecaster, and he urged the introduction of revised AIRMET broadcasts designed to serve all interests.

In the second part of his address, Sir Robert dealt with the provision made by the Government for the satisfaction of the meteorological requirements of the community. He gave an outline, based on the *Annual Reports*, of the incorporation of the Meteorological Office in the Air Ministry, and said he considered that a public review of the position of the Office as part of the Air Ministry was needed because the present organization tended to give undue priority to aviation requirements.

The improvement in meteorological knowledge from which the whole community benefited had been very largely produced by the demands of aviation, but more attention should now be paid to the needs of agriculture and other industries. The slogan " Meteorology in the service of production " should be the guide. He also urged the installation in Britain of automatic telephone weather information services such as are to be found in the United States and on the continent of Europe.

The President also suggested that the Society should set up interest groups, say for agriculture and horticulture, education, engineering, fisheries, and non-scheduled flying, domestic and social, for the discussion of the particular meteorological requirements of the interest in question.

Sir Robert said, in concluding, that the views he had expressed were entirely his own, and that he had not consulted the Director of the Meteorological Office or other Fellows of the Society in the preparation of his address.

PHYSICAL SOCIETY

At the annual general meeting of the Physical Society in the Royal Institution on Wednesday, May 2, Professor S. Chapman, F.R.S., gave his presidential address which had been postponed from last year because of his departure for the United States. The present President, Professor L. F. Bates, F.R.S., took the Chair. The title of the lecture was " Some phenomena of the upper atmosphere ".

After giving a brief history of the development of the study of the upper atmosphere from the early notions of a finite atmosphere with a continual temperature lapse with height, modified later by the work of Teisserenc de Bort and W. H. Dines and others to the notion of the isothermal stratosphere, Professor Chapman went on to discuss the modern ideas of temperature structure and the theory of the high temperatures of over 1,000°A. in the outer fringes of our atmosphere. The existence of a temperature maximum at 40 Km. was first detected by anomalous sound propagation while the temperature minimum at 80 Km., which at first seemed to clash with the theory of the maximum, was first worked out by Vegard from the band spectra of auroræ. These observations have been confirmed by observations on meteor trails.

The diurnal pressure variation had been shown by G. I. Taylor to be due to the solar tide in the atmosphere which, because of its natural period of nearly 12 hr., is amplified a hundred times by resonance. It can be shown that a natural period of 12 hr. requires a temperature minimum above 60 Km.

Attempts have been made to obtain samples of the air at high altitudes to test the theories of stratification, and samples taken by means of rockets from 60 Km. showed no change in the composition. It is expected that samples will soon be obtained from 100 Km. where, it is believed, dissociation of oxygen molecules takes place. Professor Chapman suggested that the names " turbosphere " and " homosphere " be given to the two regions of the atmosphere in which, in the first case, turbulent mixing takes place and, in the second, where no vertical mixing should occur. Mention was made of the various methods tried to obtain measurements of temperature and density from high levels. For temperature measurements these included the sound-ranging method which required elaborate ground organization, direct recording of the shock wave

angle at the nose of a rocket, the release of grenades at fixed intervals from a rocket and, for the density, the observations of the scatter from a modulated searchlight beam, such as is being done now in Alaska, where measurements up to 60 Km. have been made in the very clear atmosphere there.

Although the existence of the temperature increase in the upper ionosphere is fairly certain and the presence of the temperature maximum due to absorption by ozone has been established, nevertheless, the radiative balance of the upper atmosphere has not yet been worked out. It was hoped that a new method of laying artificial " meteor trails " of sodium vapour from rockets, suggested by D. R. Bates, would provide useful data on winds at high levels.

Dealing with the light of the night sky, Professor Chapman mentioned that the oxygen, nitrogen and sodium lines were enhanced at twilight and that the continuance throughout the night of the sodium emission had not yet been explained; it must mean that the sodium atoms could draw on local energy by some means unknown. Another recent discovery was the infra-red emission by hydroxyl (OH). Doppler broadening of the H_β and H_γ lines in the auroral spectra observed by C. W. Gartlein and the displacement of the H_α line observed by A. B. Meinel in observations on auroræ in the direction of the magnetic zenith showed that particle velocities of 3,000 Km./sec. must be reached. The theory of the existence of the hydrogen lines, first proposed by Lord Cherwell, was that the particles left the sun as protons which, on reaching the earth's atmosphere, ionized and excited other atoms, then acquired electrons so becoming hydrogen atoms, which then produced the hydrogen line.

The effect of cosmic rays was mainly in the formation of new gases by nuclear reactions. Suspected evidence for the escape from the atmosphere of fast-moving particles was the phenomenon during disturbed conditions of the F layer rising and disappearing into space to be replaced after about one hour by a new F layer. Calculations can be made from daily magnetic variations of the electric currents in the ionosphere. By this means the form and intensity of the current flow but not its height can be obtained. Isopleths of current flow had been sketched and showed that on disturbed days the normal circulation pattern was replaced by an overall flow and by two intense circulations near the magnetic pole in which two zones of maximum convergence coincided with the regions of maximum occurrence of auroræ. From the analogy with the jet stream of meteorology, Professor Chapman suggested that the name for these zones of intense current flow should be the " electrojet ". From the observations of the Observatory of Huancayo there was evidence of another " electrojet " in the tropics covering from 2° to 3° of latitude, and the Magnetic Association now meeting in Brussels were arranging an expedition to make the necessary measurements to verify this theory.

LETTERS TO THE EDITOR

" John Constable's clouds "

In the review of " John Constable's clouds " in the February issue of the *Meteorological Magazine* it is stated that Howard's paper " On the modifications of clouds " appeared in 1820. It is not clear whether this date is quoted from the book under review but it is wrong, as the paper was first printed as early as 1803 in the *Philosophical Magazine.* It was later reprinted several times—in Rees's " Cyclopaedia ", Nicholson's *Philosophical Journal* (Vol. 30), the 2nd

edition of Howard's " Climate of London ", etc. One edition, in 1865, was illustrated by lithographs, most of them taken from watercolours by Howard, but that was after his death. For Howard was " satisfied, both by reflection and experience, that the real student will acquire his knowledge in a more solid manner, by the observation of nature, without the aid of drawings, and that the more superficial are liable to be led into error by them."*

Plates were included in the 1803 publication, but are missing from my copy. Can anyone state whether Howard had reached the view expressed in the above quotation in time to have the plates removed from some issues?

F. E. DIXON

81 Ranelagh Road, Dublin, Ireland, April 25, 1951

[The author of " John Constable's Clouds " states (p. 7) that Howard's classification of clouds was first published in the *Philosophical Magazine* in 1803. His point is, however, that the painting by Constable of a group of cloud studies in 1821–22 was occasioned by the publication of the classification in 1820 in the first edition of Howard's " Climate of London ". In fact, Howard says he has found that the " copying of a particular form of each modification . . . . tends to limit too much the reader's views . . . . while the exhibition of many varieties will only serve to puzzle him." Plates are included in the copy of the 1803 paper in the Meteorological Office Library.—Ed. *M.M.*]

Duststorm at North Front, Gibraltar

Visibility over the western Mediterranean is occasionally limited by the widespread diffusion of dust, but, in the vicinity of Gibraltar, this normally produces only a slight haze. The main dust-producing areas are well to the south of Gibraltar, and the Atlas Mountains prove an effective barrier to any extensive northward movement of dust. Minor dust-producing areas are located in the French Moroccan coastal plain, particularly around Casablanca, Rabat and Port Lyautey, where there are extensive areas of very sandy soil. Duststorms developing in this area are usually quite local, and are rarely observed north of Port Lyautey.

However, at 1830 G.M.T. on December 5, 1950, for the first time on record, the visibility at Gibraltar was reduced to less than 1,000 yd. by dust and sand. The duststorm was associated with a strong south-south-westerly wind, averaging 30 kt. with gusts to 60 kt. for a short period, just before a pronounced cold front. A perceptible deposit of reddish brown dust was noted in many places throughout the Colony. The frontal rain commencing 25 min. later also contained a proportion of dust, and the effect of this was particularly noticeable on all metallic surfaces, which were quickly spattered with a reddish brown paste.

The synoptic charts for 1200 G.M.T. on December 5 showed a depression off Cape St. Vincent moving rapidly east-north-east. The associated cold front at this time was lying north-north-east to south-south-west about 100 miles west of the Moroccan coast, and at 1500 was approaching Casablanca. Surface winds freshened rapidly ahead of the cold front, and by early afternoon stations in French Morocco were reporting south-westerly winds of between 25 and 35 kt. Duststorms, reducing visibility to less than 500 yd., were reported at

*HOWARD, L.; The climate of London. London, 2nd edn 1883, Vol. I, p. lii.

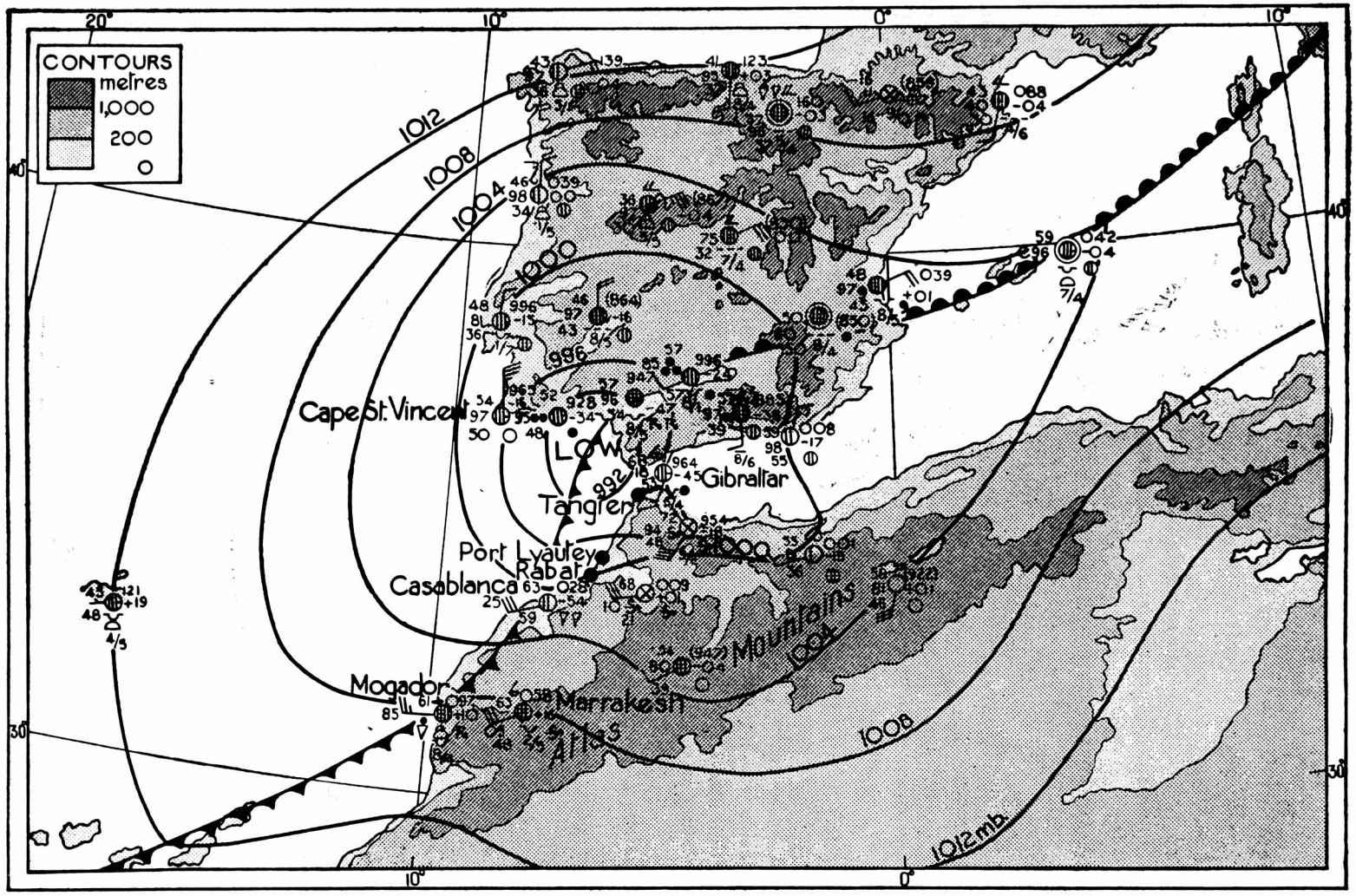


FIG. I—SYNOPTIC CHART, 1800 G.M.T., DECEMBER 5, 1950

Port Lyautey at 1200 and at Casablanca and Rabat at 1500. The dust moved quickly north-eastwards up the coast and, during the late afternoon, was observed at Tangier. The synoptic chart for 1800 is reproduced in Fig. 1. Duststorms were reported at that time from the interior and Mediterranean coast of Morocco.

Conditions at Gibraltar during the early afternoon were generally cloudy with scattered showers and light variable winds. At 1500 the wind changed abruptly to south-south-westerly and increased to 10–20 kt. After 1800 the wind freshened rapidly, reaching a maximum of 32 kt. with gusts to 60 kt. by 1900. Visibility at first was generally 7–10 miles but thickening haze after 1700 caused a deterioration to 2 miles. The main body of dust arrived at 1830 and the visibility was at once reduced to 400 yd. Frontal rain commenced at 1855 and, shortly afterwards, the visibility improved to 2 miles.

The 1345 Gibraltar upper air temperature observations showed an inversion from 950 to 920 mb. Above this level, temperature decreased at the rate of 4°F./1,000 ft., and it seems probable that over French Morocco, where screen temperatures of over 75°F. were reported, the lapse rate equalled or exceeded the dry adiabatic from the surface to 6,000 ft.

Conditions favourable for the development of duststorms over French Morocco are not uncommon at this time of the year but it is phenomenal for so much dust to be carried so far north. A possible explanation is that the unseasonal very dry weather over Morocco during the four months before this event resulted in an unusually loose top soil in many areas, which was easily lifted and disturbed by strong winds.

A. WARD

Gibraltar, December 7, 1950

Ablation in the Scottish Highlands

In his letter on this subject in the February issue, Mr. H. H. Lamb states that he is interested in the probable effect of rainfall on ablation, as distinct from air temperature. Fortunately observations of rainfall were included in the survey.

Measurable rainfall was observed on 13 days during the period covered by the survey, and the daily amounts can be placed into four groups, with a minimum of four observations per group. The average daily ablation associated with each is given in the following table:—

			inches	
Daily rainfall	trace	0·01–0·04	0·04–0·10	>0·10
Daily ablation	4·65	3·22	2·32	3·90

The number of available observations is admittedly small, but there is a distinct indication of greater ablation associated with the heaviest rainfall group, irrespective of temperature. The greatest daily rainfall was 0·344 in. on the 20th, when the associated ablation was 3·7 in., the total fall for the whole period being 1·559 in.

It would seem that in summer the least ablation occurs on days with prolonged drizzle and hill fog.

D. L. CHAMPION

47 Norrys Road, Cockfosters, Herts., May 14, 1951

Ablation of snow deposits

Mr. H. H. Lamb raises the interesting suggestion that warm rain, even in winter, may be a more effective agent of ablation than spells of warm, dry weather. From my study of Y Ffos Ddyfn, on Carnedd Llewelyn, consequent on the researches of the late J. R. Gethin Jones, I think he has come to the right conclusion. No encampments have been made to measure daily rates of ablation, but sufficient is known to show how effective warm rain is in melting the snow. This was particularly in evidence in 1947 when, despite the excessive accumulations during the preceding severe winter, the winter snow had all gone by May 22, following a warm and rainy April and May.* In contrast, in 1919 the snow lingered until July 2, after a much more moderate winter, and it survived a warm May—but the spring months were dry, with little warm rain.

Mr. Lamb is also correct about warm rain in the winter. For instance, in 1912 the snow lay only until April 26; this was clearly the result of excessive rainfall with temperatures well above normal in the March of that year.

I suspect that there is another factor, which Mr. Lamb has not mentioned. Y Ffos Ddyfn is a gully which faces nearly south; in the early summer or late spring the dwindling snow-bed is well sheltered from winds from all quarters except southerly, and it is notable how in years of late survival of the snow that there has been a scarcity of southerly winds during the last few weeks of the snow-bed's existence.

S. E. ASHMORE

11 Percy Road, Wrexham, May 25, 1951

NOTES AND NEWS

Funnel cloud at Palisadoes, Jamaica

At 1.45 p.m. on December 9, 1950, I observed a cone-like appendage from a cumulonimbus cloud about 12 miles north-west of the station. The cloud base was 3,000 ft. and its top 12,000 ft. There was a slight shower at the time from the cloud.

This cone-like appendage appeared slightly to the rear of the shower and its behaviour was interesting to watch. The first half of its length appeared to have been oblique, that is in relation to the cloud, while the rest of it was more or less vertical. It oscillated greatly in length, sometimes over 2,000 ft. (approximately) while at times it was much shorter. At one time it actually touched the very low hills under it. During all this time it maintained the shape previously described. It lasted for 10 min.

Half an hour later, the cloud tops rose higher and broke through a layer of altocumulus and the shower became more general in character.

A. L. CROSDALE

At the time of the waterspout which I saw myself, there was an almost stationary cold front lying across Jamaica. The low cloud which had been 1 okta of cumulus and stratocumulus over the mountains began to build up to the west and by 3.0 p.m. was 5 oktas in this area. The upper winds were light NE., less than 5 m.p.h. to 15,000 ft. Light showers were frequent to the

*ASHMORE, S. E.; The late-surviving snow-bed on Carnedd Llewelyn. *J. Glaciol., London*, 1, 1948, p. 205.

north-west and west of the station, and at 6.0 p.m. there was a slight one at Palisadoes after which the clouds dispersed rapidly.

The peculiar point about this phenomenon was that it occurred to the rear of the light shower, not in the shower, whilst the cloud was not a vigorous one by tropical standards. I have made inquiries of any damage or heavy deluge in the area concerned but it is possible that the active section occurred over the bush, sparsely inhabited and covered by scrub, so it would pass unnoticed.

I presume the phenomenon was more in the nature of a weak tornado rather than a waterspout.

R. K. PILSBURY

Abnormal rainfall, Trinidad and Barbados

The Senior Meteorological Officer, Piarco, Trinidad, reports that the rainfall in Barbados and Trinidad for February 1951 (the dry season) has been abnormally high and the damage to crops in Trinidad has been extensive. At one stage it was anticipated that most of Trinidad's sugar crop would be lost and his Office was inundated by inquiries from sugar planters, the Press etc. Preliminary data indicate that the Barbados rainfall is the highest for February for a hundred years whilst the Trinidad rainfall is 50 per cent. above the highest for ninety years.

Waterspouts at West Kirby, Cheshire and Llandudno, Caernarvon

Rev. E. Robinson, climatological observer at West Kirby, reports as follows: "Three separate waterspouts were observed moving in a westerly direction off the West Kirby shore at 1830 G.M.T. on Friday, April 27, 1951. They were travelling rapidly. At the same time the wind force rose with great gusts accompanied by heavy hail and sleet at this station, and for a mile or two inland."

Mr. Glyn A. Roberts, observer at Llandudno, reports that two waterspouts were seen off Llandudno at 0645 G.M.T. on the same day. Rain and hail fell from the cloud from which the waterspouts were hanging. The larger of the two waterspouts passed over the beach on to farm land and broke up. It is stated to have had a height of 100–150 ft. and a track width of 20–60 ft.

The British Isles were in a fresh polar air stream at the time and squally showers of rain, hail or sleet from cumulonimbus clouds were occurring all over the country. The waterspouts were not associated with a definite front.

Extreme upper air temperatures over the British Isles

In a letter published in the November 1950 *Meteorological Magazine* Mr. Murray quotes the very low temperatures at 700 mb. and 500 mb. over Leuchars on April 25, 1950, as being probable records for that month for south-east Scotland. This conclusion is based on a comparison of the recorded temperatures with minimum values given by Miss F. M. Jones, which were, however, obtained from *ballon-sonde* ascents.

A detailed examination of extreme temperatures recorded during radio-sonde ascents over the British Isles from about 1942 to 1946 was made in the Upper Air Section of the Meteorological Office some time ago in order to have reliable values for inquiries for such data. It was found that extremes taken from

EXTREME UPPER AIR TEMPERATURES RECORDED BY RADIO-SONDE IN THE BRITISH ISLES

Period.—June 1943–1946 (maximum), 1942–46 (minimum)

Height	MAXIMUM TEMPERATURES								MINIMUM TEMPERATURES								Height
	Reliable values				Unconfirmed values				Reliable values				Unconfirmed values				
	Temp.	Station	Date	Time	Temp.	Station	Date	Time	Temp.	Station	Date	Time	Temp.	Station	Date	Time	
mb.	°F.			G.M.T.	°F.			G.M.T.	°F.			G.M.T.	°F.			G.M.T.	mb.
40	−28	Lerwick Larkhill	30-12-45 16-6-44	0000 1200	...	...	...	...	−104	Penzance	5-12-46	0600	−107±2	Stornoway	*-3-45	0600	40
60	−37	Lerwick	3-7-45	1200	...	...	...	...	−107	Stornoway	16-1-45	0000	...	...	...	...	60
80	−33	Leuchars	28-6-44	1200	...	...	...	...	−107	Stornoway	16-1-45	0600	...	...	...	...	80
100	−35	Lerwick Leuchars	14-8-43 28-6-44	0600 1200	−33	Lerwick	14-5-45	0600	−103	Fazakerley Lerwick Lerwick Stornoway	1-1-44 9-3-45 22-2-43 16-1-45	0600 0000 2000 0600	−120	Penzance	3-2-46	0600	100
130	−36	Leuchars	28-6-44	1200	...	...	...	...	−106	Downham Mkt.	29-12-44	0000	−113	Penzance	3-2-46	0600	130
150	−29	Lerwick	22-6-43	0000	...	...	...	...									
170	−30	Lerwick	9-8-43	0000	−29	Leuchars	1-8-46	1200	−113	Fazakerley	26-2-43	1200	−121	Fazakerley	1-1-44	0600	150
200	−28	Lerwick	8-8-43	1800	−17	Larkhill	28-9-43	0000	−108	Downham M. Fazakerley Lerwick	27-1-44 2-1-44 1-1-45	1800 0600 0000	−110	Fazakerley	1-1-44	0600	170
300	−9	Fazakerley	8-8-43	0000	...	...	...	...	−103	Lerwick	8-3-44	0000	−109	Stornoway	28-12-44	1200	200
400	9	Fazakerley	8-8-43	0900	...	...	...	...	−87	Downham Mkt.	21-1-45	0600	−92±2	Leuchars	*-1-45	0600	300
500	26	Penzance	8-8-43	1200	...	...	...	...	−69	Lerwick Leuchars Stornoway	23-1-45 24-1-45 26-1-45	1800 1800 0000	−77±2	Leuchars	*-2-45	1800	400
600	33	Penzance Penzance	18-8-43 31-8-43	1200 1200	...	...	...	...	−50	Stornoway	19-1-45	0600	−52±2	Leuchars	*-1-45	1800	500
700	51	Penzance	8-8-43	1200	53±2	Stornoway	*-5-44	0600	−32	Lerwick	27-2-44	0000	...	...	...	...	600
800	63	Penzance Larkhill Fazakerley	17-8-43 17-8-43 17-8-43	1200 1800 1800	...	...	...	...	−14	Lerwick	27-2-44	0000	...	...	...	...	700
									1	Lerwick Stornoway Leuchars Lerwick	27-2-44 19-1-45 19-1-45 11-12-45	0000 1800 1800 1200	...	...	...	...	800
900	71	Fazakerley Fazakerley Larkhill	31-7-43 31-7-43 31-7-43	0600 1200 1200	...	...	...	...	11	Leuchars	29-1-45	0600	...	...	...	...	900

*These dates are not known. The information is extracted from frequency tables with values given in 5-degree ranges.

monthly tabulations could not be considered satisfactory as a scrutiny of ascents giving extremes often revealed that they were unreliable. The table of extremes given on p. 201 was compiled after carefully examining all the ascents quoted; many values were rejected before arriving at these final figures.

The " reliable values " are those which could be accepted with reasonable confidence. The " unconfirmed values " are those which either could not be checked as the original records were not available, or appeared doubtful but could not be rejected with reasonable confidence. For maximum temperatures, however, in particular those at the lowest pressures, this must be interpreted as meaning either that they were considered good ascents by the observing station or that they showed no remarkable deviations from comparable ascents. It is still uncertain to what extent radio-sonde temperatures are affected by insolation and instrumental defects.

Maximum temperatures are those recorded after June 1943; this is approximately the date when an improved radiation shield and longer suspension were brought into use.

It will be seen that the value of −6°F. at 3 Km. was surpassed by a value of −14°F. at Lerwick, and, interpolating between the 600-mb. and 500-mb. extremes, an estimated minimum of −41°F. at 550 mb. is found for north Scotland which is also lower than the 5-Km. value given by Miss Jones.

These radio-sonde values were also recorded during January and February ascents and the Leuchars values given by Mr. Murray may well be records for April.

D. DEWAR

35th Physical Society Exhibition

Meteorological instruments were shown on several stands at the Physical Society's annual exhibition of scientific instruments and apparatus held on April 6–11 at the Imperial College.

Meteorological Office stand

Wind-direction recorder using a single pen, operated by magslip transmission, writing on a 720° chart with north lines at the centre and sides of the chart (see photographs facing p. iii of cover).

Experimental barograph with several improvements such as a means of lowering or raising the aneroid chamber so as to cover pressures down to 750 mb., an adjustable link for altering the scale value, and a time marker which cannot strain the transmission.

Fog-density indicator.—A number of small electric lamps are surrounded by a rectangular arrangement of photo-electric cells. In clear air no light from the lamps is received by the photo-electric cells, but light scattered by fog does reach the photo-electric cells and the intensity of the photo-electric cell output is a rough measure of the fog density. The instrument is intended to be flown on a captive balloon and the cable to the balloon carries the photo-electric cell output.

Photo-electric visibility meter[1] working over a range of a few yards. A puff of cigarette smoke in the beam is used to simulate fog.

Frost-point hygrometer with photo-electric detection of the frost point and automatic control of thimble temperature.[2]

Messrs. Casella's stand

Direct distant-reading sensitive anemometer having a Sheppard cup anemometer with a shutter fixed to the spindle arranged to vary the light falling on a photo-cell as the shaft turns. By varying the number of apertures in the shutter the scale can be spread over various parts of a range from ½ to 100 m.p.h.

Aspirated psychrometer using thermocouples.—This instrument is fitted with thermo-couples instead of the usual thermometers and is electrically aspirated. A constant wetting device is provided for the wet " bulb " so that the observer need not be continuously present.

Duvdevani dew gauge.[3]

" *Sword* " *hygrometer* for industrial use.—The " sword " is hollow and contains the hairs to which the air obtains access by holes at the end of the " blade ". The relative humidity is shown on a scale in the handle.

Negretti and Zambra showed a precision aneroid for mining use.

British Electrical and Allied Industries Research Association

Anemometer for measuring gusts.—A small, hollow, perforated sphere is attached to one end of a pivoted rod. Movements of the sphere, due to gusts of wind, are recorded electrically, making use of a transducer. The response time is less than 0·1 sec.[4]

Chemical Defence Experimental Establishment

Photo-electric drop counter.—The passage of a drop through a beam of light produces an electrical impulse at the photo-electric cell. The instrument operates in the drop-size range from several millimetres to 0·25 mm. diameter and counts at rates up to 400 a minute.

Fielden Electronics Ltd

Electronic hygrometer.—The instrument employs thermistors, two dry and one wet. One dry and one wet thermistor function as a normal wet- and dry-bulb hygrometer; the third element is arranged in a special circuit to compensate for changes in ambient temperature so that the instrument records the relative humidity directly.

[1]*Met. Mag., London,* **79**, 1950, p. 114.
[2]*Met. Mag., London,* **80**, 1951, p. 118.
[3]*Met. Mag., London,* **76**, 1947, p. 160.
[4]*Met. Mag., London,* **80**, 1951, p. 115.

Shielded thermometer mounts

In the photograph facing p. 9 of the January 1951 issue of the *Meteorological Magazine* can be seen small shielded thermometer mounts which were used with minimum thermometer and distant-reading thermograph bulbs to measure temperatures under glass cloches. Such a small, cheap, and portable screen has been found necessary for many such experiments* in agricultual meteorology.

The main virtue of the standard Stevenson screen is that it creates a standard exposure which can be reproduced elsewhere. It does not claim to ensure the recording of the true air temperature; the readings therefrom may be untrue, but at least they are uniformly untrue.

During the months August to December 1949, experiments were carried out at Bristol to test the efficiency of these shielded mounts, both in comparison with Stevenson screens and between themselves.

*For example: SMITH, L. P.; Temperature under Dutch lights. *Met. Mag., London,* **80**, 1951, p. 50

A Stevenson screen, containing two minimum thermometers, and two mounts, each containing one minimum thermometer, were set up in identical exposures over a grass lawn. During the experiment the readings of the index and the meniscus were taken; individual thermometers were interchanged after each reading, and the order of reading was reversed each day.

The results so obtained were analysed statistically and the following conclusions drawn:—

When similarly exposed on a homogeneous site, the readings of night minimum temperatures of spirit thermometers in the shielded mounts rarely differed by more than two or three tenths of a degree; this is the order of difference which is obtained from Stevenson screens similarly compared.

The minimum recorded in a shielded mount was lower than that recorded in a Stevenson screen by about $\frac{3}{4}$°F. on cloudy or windy nights and about 1°F. on radiation nights. The maximum discrepancy was about 2°F.

For spot readings of day temperatures differences of the order of $\frac{1}{2}$°F. between thermometers in shielded mounts can be regarded as significant.

In cloudy conditions the spot day readings from shielded mounts can be from $\frac{1}{2}$° less to $1\frac{1}{2}$°F. more than those from a Stevenson screen. In bright sunshine the readings were rarely less than the standard ones and could be as much as $2\frac{1}{2}$°F. more. On a hot sunny midsummer day the difference might be even greater.

In general it may be said that the degree of uniformity of readings from shielded mounts is very similar to that obtained from standard screens. The absolute values are mainly less by night and greater by day, but not by any such amounts that would render their use for field experiments inadvisable, provided that the probable errors in hot sunlight are taken into consideration.

A full account of the experiment will be published elsewhere.

R. W. GLOYNE
L. P. SMITH

New Japanese meteorological publication

The first volume of the new Japanese meteorological publication, *Papers in Meteorology and Geophysics*, of the Meteorological Research Institute, Tokyo, has been received. The papers are all in English.

The volume contains twenty-four papers covering a wide field. These are papers on dynamical meteorology, synoptic meteorology, instruments, statistical analysis of observations, applications of meteorological information in house design, evaporation, radiation, atmospheric electricity and terrestrial magnetism. A particularly interesting paper is Dr. Arakawa's description, based on a number of radio-sonde ascents, of the vertical structure of a typhoon which crossed Japan, passing very near Tokyo in August 1949.

British meteorologists will wish success to the Research Institute and its new periodical.

Present position of the Meteorological Service in Japan

Three-quarters of a century has now elapsed since the Central Meteorological Observatory was established in Tokyo on June 1, 1875.

The record of Directors of the Observatory from that time is:—

Mr. Arai, Ikunosuke, June 1875–March 1891
Mr. Kobayashi, Kazutomo, March 1891–August 1895
Dr. Nakamura, Kiyoo, August 1895–February 1923
Dr. Okada, Takematsu, February 1923–July 1941
Dr. Fujiwhara, Sakuhei, July 1941–March 1947
Dr. Wadati, Kiyoo, March 1947–

Japanese meteorologists received two sad reports in 1950, namely the deaths of Dr. S. Fujiwhara and Mr. W. Oishi, ex-Director of the Aerological Observatory.

Major scientific periodicals or serials now published by Japanese meteorological organizations are:—

Kisho-Syushi (Journal of the Meteorological Society of Japan), 1882–
Geophysical Magazine, published by the Central Meteorological Observatory, 1926–
Papers in Meteorology and Geophysics, published by the Meteorological Research Institute, Tokyo, 1950–
Geophysical Notes, published by the Geophysical Institute, Tokyo University, Tokyo, 1946–
Science Reports of the Tohoku University, 5th Series: *Geophysics*, published by the Geophysical Institute, Tohoku University, Sendai, 1949–
Umi To Sora, published by the Marine-Meteorological Society of Japan, 1921–

The major publications of Japanese meteorological observations are:—

Daily Weather Map, 1883–
Monthly Report of the Central Meteorological Observatory of Japan, 1892–
Kisho Yoran (*Monthly Geophysical Review*), (excepting 1944–46) 1900–
Aerological Data of Japan, 1947–

Under the Central Meteorological Observatory there are 5 District Central Meteorological Observatories (Tokyo, Osaka, Fukuoka, Sendai and Sapporo), approximately 150 field stations, 4 Marine Observatories (Kobe, Nagasaki, Hakodate and Maizuru), 1 Aerological Observatory (Tateno), 1 Terrestrial Magnetic Observatory (Kakioka), a Training School for Meteorological Observers and a Meteorological Research Institute. The total staff of Central Meteorological Observatory numbers approximately 5,400.

H. ARAKAWA

Geographical Journal

The Geographical Journal for March 1951 contains the text and discussion of Professor Manley's paper " The range of variation of the British climate " read at the Royal Geographical Society's meeting on January 23, 1950.

The first part of Professor Manley's paper deals with the fluctuations of annual mean temperature since 1700, with especial detail for the increase since 1925, and with the probable amplitude of earlier fluctuations of temperature since the " climatic optimum " some 5,000 years ago. The second part deals with the temperature of the last glacial and early post-glacial times in Britain. The information for the period since 1700 is based on instrumental

observations, but for earlier times a variety of evidence, meteorological (e.g. the present relation between the height of the snow-line and temperature over western Europe), botanical and geological, is assembled.

The author considers that each of the principal climatic changes, since the maximum of the last glaciation, was associated with a rise or fall in the mean temperature of the summer of only 2° or 3°F., and that the changes are attributable to the persistence over shorter or longer periods of high- or low-index circulation patterns.

A second paper of meteorological interest in the same number is by Brigadier R. A. Bagnold, F.R.S., on " Sand formation in southern Arabia " in which the formation of the sand dunes is related to wind.

G. A. BULL

REVIEWS

Die Intensität der zonalen Zirkulation in der freien Atmosphäre aussertropischer Breiten. By Hermann Flohn. *Beitr. Geophys., Leipzig*, **60**, 1944, pp. 196–209.

This paper by Flohn gives interesting figures from an analysis of the best observational material available in Germany up to 1943–44. Tables I–III are quoted from the paper.

TABLE I—MEAN ZONAL COMPONENTS AT THE 5-KM. LEVEL IN VARIOUS LATITUDES

	Mean zonal component at latitudes (N.)					
	30°	40°	50°	60°	70°	80°
	knots					
Winter (December–February)	32	38	27	21	10	3
Summer (June–August) ...	8	20	17	10	10	6

Scalar values of individual wind speeds observed are greatest over the eastern sides of the oceans and north of 50°N., but they are not purely westerly. The strongest zonal components and the maximum occurrence of purely W. winds are in lower latitudes over the western sides of the oceans and east coasts of America and Asia (frontogenetic areas), determining the location in the hemisphere of the strongest mean zonal components in 35–45°N.

The European sector actually shows its highest zonal components of mean velocity in summer, because in winter the prevailing upper winds are northerly or north-westerly there.

TABLE II—SEASONAL VARIATION OF MEAN ZONAL COMPONENTS IN THE 5-KM. LEVEL AT 40°N.

	Mean zonal component in various sectors		
	North America 75–125° W.	Europe 5° W.–35° E.	Northern hemisphere
	knots		
Winter (December–February) ...	46	13	38
Summer (June–August)	21	16	20

The constancy of westerlies in the lower latitudes over eastern Asia and the United States is shown by some remarkable winter values of mean vector wind velocity: Japan (36°N.) at 4 Km. W., 46 kt.; at 10 Km. W., 140 kt. (260 Km./hr.); New England, U.S.A. (40–45°N.) at 4 Km. W., 37 kt. Flohn remarks that on account of the semi-permanent strong upper westerly flow stationary anticyclones rarely occur over eastern North America and, presumably, over eastern Asia; most highs travel almost as fast as depressions across these regions.

Conditions are presumed to be different in many respects in the southern hemisphere due to absence of monsoonal heating and cooling effects. Flohn, who worked up the results of the *Schwabenland* expedition of 1939, uses data for the South-Atlantic sector to illustrate these differences.

TABLE III—COMPARISON BETWEEN NORTHERN AND SOUTHERN HEMISPHERES OF THE MEAN ZONAL COMPONENTS IN 35–65° LATITUDE

Height	Mean zonal component			
	Northern hemisphere		Southern hemisphere	
	Winter	Summer	Winter	Summer
	knots			
5 Km.	27	15	(46)	36
Surface	3	1·6	20	17
Westerly thermal component (0–5 Km.) ...	24	13	26	19

It is interesting that the zonal components of circulation in the southern summer exceed those for the northern winter and that there is much less variation from summer to winter in the southern than in the northern hemisphere.

The greater thermal components of zonal circulation in the south are clearly due to the lower temperature in the Antarctic than in the Arctic troposphere, particularly in summer. South of 50°S. precipitation falls predominantly as snow even in summer—at least in the Atlantic-Ocean, Indian-Ocean and Australian sectors.

The most striking difference between the northern and southern hemispheres is, however, between the mean values for zonal components of surface winds and also, of course, the surface pressure gradients.

Meridional circulations do occur in the southern hemisphere, though less often than in the northern. Argentine meteorologists have drawn attention to the persistence of a trough in the upper wind flow east of the Andes which is the most formidable barrier in the world to the free zonal flow[1]. This trough may be considered to play the part of an anchor in the wave-train of the upper westerlies. Nevertheless it is not quite always present. The strongly predominant zonal character of the southern-hemisphere circulation is shown beyond doubt by Flohn's figures.

The grand-scale heat interchange between low and high latitudes seems to have a different character in the two hemispheres. In the north there is evidence that the greatest heat exchanges are achieved in an orderly manner by meridional circulations and other patterns involving the development of blocking anticyclones as cut-off warm eddies in high latitudes[2]. In the southern hemisphere such blocking anticyclones hardly occur at all. Estimates quoted by Flohn show that rainfall between 35° and 65°S. averages nearly one third greater, and between 50° and 55°S., nearly one half greater than in corresponding northern latitudes. These differences are of course bound up with the different proportions of land and sea in the corresponding zones of the two hemispheres; and as a result thereof, if we may accept the estimated rainfall figures, the occlusion process, by more or less disorderly variations of the westerlies associated with passing depressions, appears capable of transporting larger quantities of heat towards high latitudes in the southern hemisphere than in the northern. Periods of increased thermal gradient between tropics

and poles, due to whatever cause, may therefore result in increased zonal flow in the southern hemisphere and decreased zonal flow with development of blocking anticyclones in the northern hemisphere.

H. H. LAMB

REFERENCES

1. BOFFI, J. A. ; Effect of the Andes Mountains on the general circulation over the southern part of South America. *Bull. Amer. met. Soc., Lancaster Pa.*, **30**, 1949, p. 242.
2. ELLIOTT, R. D., and SMITH, T. B.; A study of the effects of large blocking highs on the general circulation in the northern-hemisphere westerlies. *J. Met., Lancaster Pa.*, **6** p. 67.

An investigation on some aspects of the effect of land and sea breezes. By F. Balkema, *Meded. ned. met. Inst., De Bilt*, B, **2**, No. 13, 1950. pp. 50. *Illus.*, Staatsdrukkerij-en Uitgeverijbedrijf, 's-Gravenhage and Utrecht, Price *fl:* 1.50.

This investigation is the first in which a special study is made of land and sea breezes over Holland. After a general introduction, the author analyses 10 years' wind observations for IJmuiden on the Dutch coast. Diagrams of the vector mean wind at each hour of the day for each month of the year show a marked diurnal variation of wind, particularly during the summer months.

As a measure of the differential heating of the air over land and sea, the author computes values of the mean daily " relative insolation " from observations of insolation at De Bilt, 35 miles inland from IJmuiden, but unfortunately he fails to give a clear definition of the term " relative insolation".

The wind observations are classified according to the relative insolation and the gradient wind, and a series of diagrams shows that, in general, increased insolation results in an increased on-shore wind component during the day, suggestive of a sea-breeze effect. Exceptions occur with gradient winds between north-east and east when there is an increased off-shore component. The latter effect is shown to be due to the formation of a thermal depression over south-east Holland.

The author is unable to find any close correlation between the magnitude of the sea-breeze effect, the stability of the air, and the difference in temperature of the air over land and sea, and concludes that the sea-breeze effect is more closely correlated with the relative insolation. Nevertheless, Table VI does show some evidence of a correlation between the pronounced sea breezes and increased stability, which the author appears to have disregarded and which might repay further investigation.

In later chapters, the author gives a comprehensive account of recent theoretical investigations into the structure of the sea breeze, with particular reference to the effect of lapse rate. This proved very difficult to treat theoretically, and no firm conclusions were reached.

To the reviewer, there appear to be few advantages in using values of relative insolation as a measure of the differential heating of the air. As the author points out, the amount of heat supplied to the atmosphere will, for the same insolation, vary according to the water content of the soil and the type of vegetation. In practice, therefore, the daily variation of the temperature difference of the air over land and sea, meaned throughout the convective layer, is a better guide.

This is an interesting work, but unfortunately spoiled by a stilted translation which gives rise to a great deal of obscurity and ambiguity.

ALAN WARD

BOOKS RECEIVED

Tätigkeitsbericht, 1948–49. Schweizerisches Forschungsinstitut für Hochgebirgsklima und Tuberkulose in Davos, enlarged from *Schweiz. med. Wschr., Basel*, Jg. 80, 1950, p. 239. $8\frac{1}{4}$ in. × $5\frac{3}{4}$ in., pp. 13, Benno Schwabe & Co., Basel, 1950.

Die Klimaverhältnisse von Wiesen. By W. Mörikofer. *Jber. naturf. Ges. Graubünden, Chur*, **82**, 1950, pp. 53–88.

Theoretisches und Konstruktives zur Messung der Abkühlungsgrösse. By H. Wierzejewski. *Arch. Met. Geophys. Bioklim., Wien*, B, **2**, 1950, pp. 65–85.

Tagesgang und Komponenten der Abkühlungsgrosse. By Charlotte Henneberger. *Arch. Met. Geophys. Bioklim., Wien*, B, **2**, 1950, pp. 86–119.

L'importance des particularités du climat local pour les stations climatiques. By W. Mörikofer. *Věstn. čsl. fysiatrické společn. Praha*, Cís. 1–6, 1948, pp. 28–34.

Der Luftdruckvariograph als Hilfsmittel bei der Wetteranalyse. By Walter Schüepp. *Verh. schweiz. naturf. Ges., Lausanne*, 1949, pp. 113–14.

A study of the distribution of rainfall in the peninsula associated with some pre-monsoon storms. By P. N. Boothalingam and V. Srinivasan. *Sci. Notes India met. Dep., Delhi*, **11**, No. 132, pp. 9–16. *Illus.* Manager of Publications, Delhi, 1950, Price: *Rs.* 3/14/– or 6*s.* 3*d.*

L'osservatorio meteorico di Orvieto. By C. Lo Iacono, *Riv. aero., Roma*, **26**, Nr. 12, pp. 895–903. *Illus.* Associazione Culturale Aeronautica, Roma, 1950.

OBITUARY

Miss Agnes J. Tolmie, O.B.E.—The Toronto *Weekly Star* of March 22, 1951, records the death of Miss Tolmie, who had been an observer at Southampton, Ontario, for the Canadian Meteorological Service since 1872. She had been in full charge of the synoptic reporting station at Southampton since 1917 and made reports three times a day until very recently. She was awarded the O.B.E. for her work during the second World War.

Miss Tolmie was well known to the staff of the British Meteorological Office set up during the war at the Air Navigation School at Port Albert, 50 miles to the south-south-west. Southampton was the only reporting station north of Port Albert and its reports were very valuable when frontal systems were approaching from north or north-west.

NEWS IN BRIEF

Mr. J. C. W. Day of 15 Dartmouth Avenue, Walsall, is anxious to add a rain recorder to the equipment of his climatological station and will be pleased to hear from anyone willing to dispose of a recorder at a reasonable price.

METEOROLOGICAL OFFICE NEWS

Sports and Athletics.—*The Air Ministry Sports* were held at the White City Stadium on June 12 in excellent weather. The Office again won the Jones Cup for the highest number of points and the Halahan Shield for the tug-of-war. Noteworthy individual performances were those of Mr. R. J. Garner, who won the 100 yards and the 220 yards championships and Miss K. N. Newman (an Assistant trainee), who won the 100 yards ladies' championship and the 220 yards ladies' scratch race.

The period during which points are allotted in the competition for the Bishop Shield ended with the annual sports meeting, and for the third year in succession

the Office were the winners. The main contributors to this were the swimmers who won every race, the athletes who gained so many points at the sports meeting, and the Harrow ladies' netball team who won the Air Ministry tournament for the third successive year.

The Office is indebted to Mr. H. A. Scotney for the time and trouble which he devotes to fostering the keen sporting spirit which plays so large a part in the achievement of our successes.

Cricket.—Cricket enthusiasts will be interested to know that the Central Forecasting Office cricket team (captain, Mr. H. E. Snow), emboldened by local successes, challenged Headquarters, London, to select a team for a " needle " match to be played at Dunstable. With wide choice of players, London was able to include Messrs. C. W. Lamb and H. G. Garnett in their team, the former acting as captain.

The match was played at Dunstable on June 4 before a crowd of spectators, in perfect weather (though not on a perfect wicket). The challengers, who won the toss and went in to bat first, were all out for 36. The London team won the match with a total of 132.

The outstanding performances of the afternoon were the wicket-keeping of C. F. Hawson for the Central Forecasting Office, the bowling of G. Needham for London and the batting of H. G. Garnett, who made a total of 50 runs for London before retiring.

Spectators and players alike declared the match an unqualified success and it is hoped that it will be the forerunner of many similar events.

Golf in Germany.—Members of the staff who play golf will be interested to learn that the Royal Air Force in Germany have an excellent nine-holes golf course located at H.Q., B.A.F.O., Bad Eilsen, and that civilian meteorological staff have the privilege of becoming full members of the club. Several members of the staff have had notable successes in various club and Command competitions, and have also represented the Royal Air Force in Germany in matches with the Army, the Control Commission and with American golfers in the United States Zone. The Chief Meteorological Officer, Mr. R. Cranna, has recently been elected captain of the club.

WEATHER OF MAY 1951

Mean pressure was over 1020 mb. in the area north of the British Isles, including Iceland and the east coast of Greenland. Mean pressures between 1015 and 1020 mb. extended over an area including the north-east Atlantic, most of the British Isles and Scandinavia; similar mean pressures existed over the Atlantic south of latitude 45° N. and in Portugal and Morocco. Mean pressures were mainly between 1010 and 1015 mb. over Europe, north and west Africa and most of North America.

The excess of pressure was most marked in the area north of the British Isles, where it was between 5 and 10 mb. Pressure over Europe was below normal, the deficits varying between 2 and 5 mb.

Mean temperatures were between 40° and 50° F. in the British Isles and Scandinavia, between 50° and 60° F. in Europe, 60° to 70° F. in the Mediterranean area and between 75° and 95° F. in north and west Africa. In the United States mean temperatures varied from 55° F. in the north to 75° F. in the south.

Mean temperature in Europe was between 2° and 5° F. below normal.

In the British Isles the weather was cool, with winds from between north and east predominating. Broadly speaking it was dry and sunny in the north-west and north but wet and rather dull in the south and east.

In the opening days a small depression off Denmark moved west across south Scotland and then swung south-west to south. Rather heavy rain fell in some areas on the 1st, while scattered thunderstorms occurred from the 1st to the 3rd; snow or sleet fell in many districts of Scotland on the 1st. On the 4th a trough of low pressure over France moved slowly north and was associated in England with heavy rain in places and local thunderstorms (2·15 in. at Bradford on the 4th and 2·30 in. at Nidderdale, Yorkshire, on the 5th). In Scotland, however, the weather was dry and sunny. On the 7th a depression over France moved north-east to Germany, while a small secondary disturbance moved south over western Scotland; a spell of cold N.–NE. winds prevailed with local slight rain or snow. Meanwhile a belt of high pressure was situated to the west and north-west of the British Isles and subsequently the centre off north-west Scotland moved slowly south-east over the British Isles and later withdrew south-westward. A period of dry cold weather ensued and lasted until the 15th, when a cold front moving south-west across Great Britain caused some rain in most places. This was, however, only a temporary break in the dry spell as, on the 16th, another anticyclone developed to the north of Scotland and moved southward to the North Sea. The weather was dry from the 16th to the 18th, apart from some rain in the south of England. A change of type occurred on the 19th, when the British Isles began to come under the influence of a complex depression over the Atlantic south of Greenland. Small secondary depressions associated with this system moved north or north-east over the British Isles and a spell of milder, unsettled weather prevailed with rain and local thunderstorms. Temperature rose to 70° F. at a number of stations in England on the 24th and 25th and touched 74° F. at Camden Square, London, on the 24th and at Hull on the 25th. On the 26th and 27th a depression moved north over France to east England, thence west across the Midlands and south-south-west to the mouth of the English Channel; heavy rain and rather widespread thunderstorms occurred on the 26th and fairly heavy rain in some parts on the 27th. Subsequently an anticyclone off the north of Scotland moved slowly south-south-east and the closing days were dry and sunny on the whole, though it was rather dull, particularly in some eastern districts, on the 29th and 30th. The 31st was the sunniest day of the month at many places (16·0 hr. at Dyce in Aberdeenshire) and temperature rose to 70° F. at a number of places in the west and north of Scotland.

The general character of the weather is shown by the following provisional figures:—

	Air Temperature			Rainfall		Sunshine
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	74	22	−2·2	140	+2	88
Scotland	71	21	−1·5	63	−7	124
Northern Ireland ...	68	29	−2·1	72	−4	114

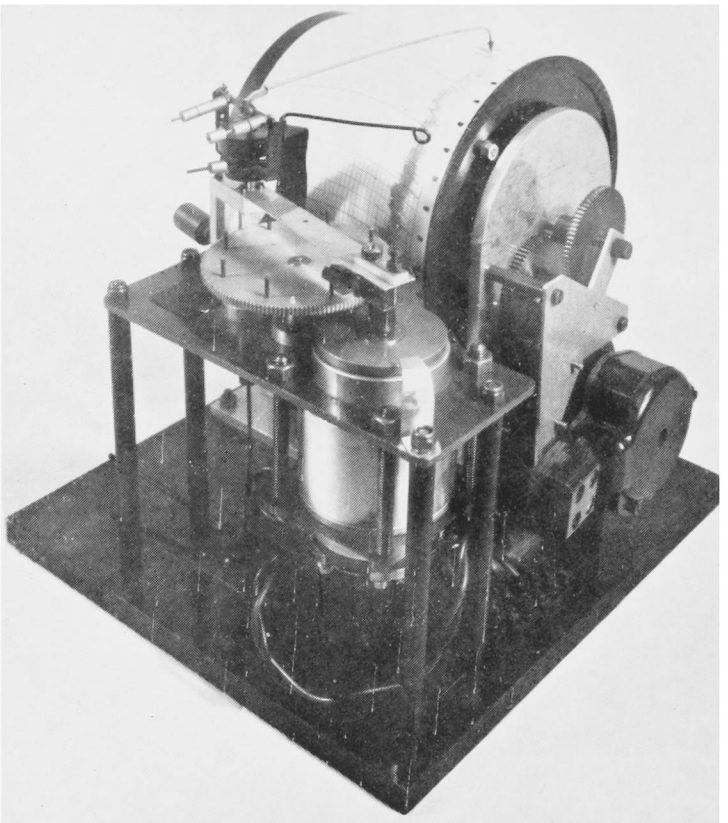
RAINFALL OF MAY 1951

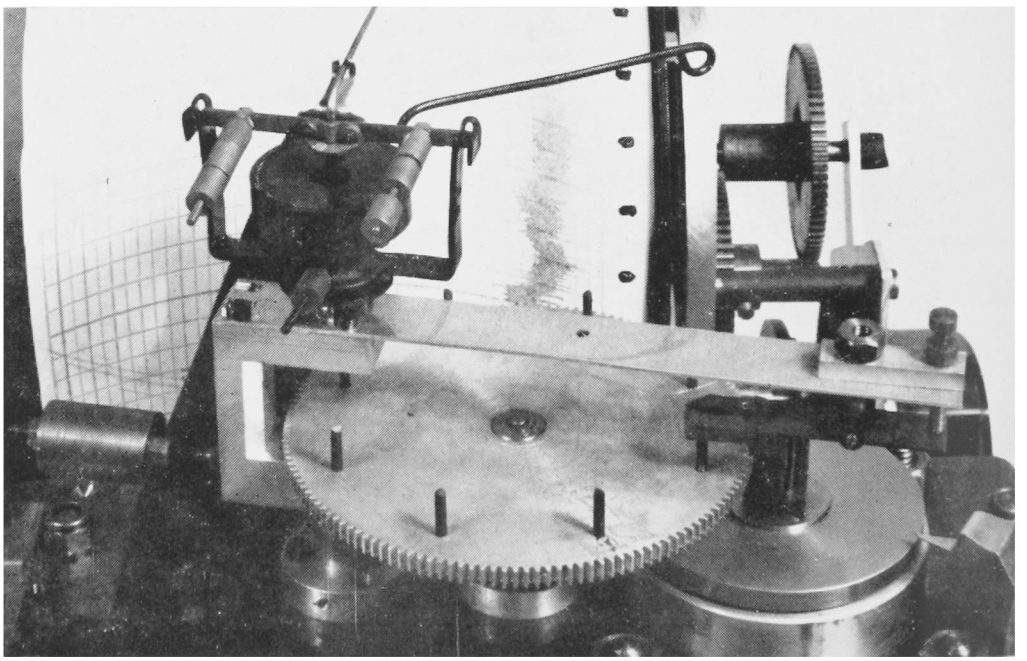
Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	2·12	120	*Glam.*	Cardiff, Penylan ...	2·51	102
Kent	Folkestone, Cherry Gdn.	2·15	128	*Pemb.*	Tenby, The Priory ...	2·29	100
,,	Edenbridge, Falconhurst	2·11	113	*Card.*	Aberystwyth	3·33	160
Sussex	Compton, Compton Ho.	2·80	126	*Radnor*	Tyrmynydd	3·71	108
,,	Worthing, Beach Ho. Pk.	2·36	143	*Mont.*	Lake Vyrnwy	3·60	112
Hants.	Ventnor, Cemetery ...	3·01	173	*Mer.*	Blaenau Festiniog ...	1·88	33
,,	Bournemouth	2·57	146	*Carn.*	Llandudno	3·09	174
,,	Sherborne St. John ...	2·95	152	*Angl.*	Llanerchymedd ...	3·03	129
Herts.	Royston, Therfield Rec.	3·06	158	*I. Man*	Douglas, Borough Cem.	3·90	156
Bucks.	Slough, Upton	2·23	133	*Wigtown*	Port William, Monreith	1·99	85
Oxford	Oxford, Radcliffe ...	2·10	112	*Dumf.*	Dumfries, Crichton R.I.	2·45	89
N'hants.	Wellingboro', Swanspool	3·47	179	,,	Eskdalemuir Obsy. ...	2·19	66
Essex	Shoeburyness	1·96	151	*Roxb.*	Kelso, Floors	2·87	149
,,	Dovercourt	2·09	150	*Peebles*	Stobo Castle	2·88	127
Suffolk	Lowestoft Sec. School ...	...	...	*Berwick*	Marchmont House ...	2·99	121
,,	Bury St. Ed., Westley H.	2·27	125	*E. Loth.*	North Berwick Res. ...	2·90	146
Norfolk	Sandringham Ho. Gdns.	2·71	148	*Midl'n.*	Edinburgh, Blackf'd. H.	3·04	148
Wilts.	Aldbourne	3·03	154	*Lanark*	Hamilton W. W., T'nhill	1·46	61
Dorset	Creech Grange... ...	3·20	157	*Ayr*	Colmonell, Knockdolian	2·01	79
,,	Beaminster, East St. ...	2·81	136	,,	Glen Afton, Ayr San ...	3·12	104
Devon	Teignmouth, Den Gdns.	2·62	143	*Bute*	Rothesay, Ardencraig ...	2·73	90
,,	Cullompton	2·66	123	*Argyll*	Morvern (Drimnin) ...	1·00	31
,,	Ilfracombe	2·93	142	,,	Poltalloch	·59	21
,,	Okehampton, Uplands	5·16	192	,,	Inveraray Castle ...	1·27	32
Cornwall	Bude, School House ...	3·62	197	,,	Islay, Eallabus	1·09	41
,,	Penzance, Morrab Gdns.	3.28	148	,,	Tiree	·70	28
,,	St. Austell	3·40	140	*Kinross*	Loch Leven Sluice ...	2·65	109
,,	Scilly, Tresco Abbey ...	2·48	147	*Fife*	Leuchars Airfield ...	1·91	98
Glos.	Cirencester	2·92	142	*Perth*	Loch Dhu	2·50	56
Salop	Church Stretton ...	3.32	131	,,	Crieff, Strathearn Hyd.	2·27	91
,,	Shrewsbury, Monksmore	3·15	162	,,	Pitlochry, Fincastle ...	1·88	89
Worcs.	Malvern, Free Library	3·55	164	*Angus*	Montrose, Sunnyside ...	1·42	70
Warwick	Birmingham, Edgbaston	3·63	170	*Aberd.*	Braemar	1·72	72
Leics.	Thornton Reservoir ...	3·29	164	,,	Dyce, Craibstone ...	1·32	52
Lincs.	Boston, Skirbeck ...	2·95	168	,,	Fyvie Castle	1·19	46
,,	Skegness, Marine Gdns.	3·05	179	*Moray*	Gordon Castle	·98	46
Notts.	Mansfield, Carr Bank ...	3·20	151	*Nairn*	Nairn, Achareidh ...	·59	34
Derby	Buxton, Terrace Slopes	2·60	84	*Inverness*	Loch Ness, Garthbeg ...	·93	37
Ches.	Bidston Observatory ...	2·85	150	,,	Glenquoich	·73	13
Lancs.	Manchester, Whit. Park	...	...	,,	Fort William, Teviot ...	·50	13
,,	Stonyhurst College ...	1·63	57	,,	Skye, Duntuilm ...	·42	15
,,	Squires Gate	2·83	136	*R. & C.*	Tain, Tarlogie House ...	1·08	52
Yorks.	Wakefield, Clarence Pk.	4·34	220	,,	Inverbroom, Glackour...	1·97	66
,,	Hull, Pearson Park ...	4·50	233	,,	Applecross Gardens ...	1·97	61
,,	Felixkirk, Mt. St. John	4·93	262	,,	Achnashellach	·83	20
,,	York Museum	3·71	186	,,	Stornoway Airfield ...	·96	40
,,	Scarborough	4·31	226	*Suth.*	Loch More, Achfary ...	2·61	59
,,	Middlesbrough... ...	4·29	223	*Caith.*	Wick Airfield	·46	22
,,	Baldersdale, Hury Res.	2·83	110	*Shetland*	Lerwick Observatory ...	·30	14
Norl'd.	Newcastle, Leazes Pk....	3·59	181	*Ferm.*	Crom Castle	1·73	62
,,	Bellingham, High Green	2.38	99	*Armagh*	Armagh Observatory ...	1·49	63
,,	Lilburn Tower Gdns. ...	3·67	159	*Down*	Seaforde	3·64	138
Cumb.	Geltsdale	2·08	81	*Antrim*	Aldergrove Airfield ...	1·33	59
,,	Keswick, High Hill ...	3·08	97	,,	Ballymena, Harryville...	1·45	51
,,	Ravenglass, The Grove	1·73	62	*L'derry*	Garvagh, Moneydig ...	1·71	67
Mon.	Abergavenny, Larchfield	3·40	127	,,	Londonderry, Creggan	1·24	47
Glam.	Ystalyfera, Wern House	3·11	89	*Tyrone*	Omagh, Edenfel ...	1·62	63

[*To face p.* 212

FIG. 2—EXPERIMENTAL HOUSE SHOWING SOME OF THE RAIN-GAUGES
Gauge 1 was only placed between gauges 3 and 5 temporarily





WIND-DIRECTION RECORDER

The wind direction is reproduced by a self-synchronous motor, part of which can be seen in the near corner of the upper photograph, and is then transmitted to the large toothed wheel (see lower photograph) by 8:1 gearing so that the angular distance between each two of the eight pegs on the toothed wheel represents a complete revolution of the wind vane. One of the pegs (extreme right-hand peg in the lower photograph) slides inside a slot within a hinged block which is connected by a lever mechanism to the pen arm. The north-wind direction is in the middle and right and left edges of the chart. As the pen reaches either edge of the chart, the peg moves out of the slot and allows the slotted block to spring back and engage with the next peg, and the pen continues recording in the middle of the chart.